Electronic Version

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Claims

[c1] A multi-mode optical fiber link comprising:

a first spatial mode converter having an input that is coupled to an output of a single mode optical fiber, the first spatial mode converter conditioning a modal profile of an optical signal propagating from the single mode optical fiber to the first spatial mode converter;

a multi-mode optical fiber having an input that is coupled to an output of the first spatial mode converter; and

a second spatial mode converter having an input that is coupled to an output of the multi-mode optical fiber and an output that is coupled to a second single mode optical fiber, the second spatial mode converter reducing a number of optical modes in the optical signal, wherein both the first and the second spatial mode converters increase an effective modal bandwidth of the optical signal.

[c2] The optical fiber link of claim 1 further comprising an optical source having an output that is coupled to an input of the single mode optical fiber, the optical source

generating the optical signal having a wavelength.

[c3] The optical fiber link of claim 2 wherein the optical source comprises an intensity modulated optical source.

[c4] The optical fiber link of claim 2 wherein the optical source comprises an electro-absorption modulated laser.

[c5] The optical fiber link of claim 2 wherein the optical source comprises an integrated laser modulator.

[c6] The optical fiber link of claim 2 further comprising a second optical source having an output that is coupled to the input of the single mode optical fiber, the second optical source generating a second optical signal having a second wavelength at the output.

[c7] The optical fiber link of claim 2 further comprising a second optical source having an output that is coupled to the output of the second spatial mode converter, the second optical source generating a second optical signal having a second wavelength at the output.

[c8] The optical fiber link of claim 1 wherein at least one of the first and the second spatial mode converters comprise a fusion splice between the multi-mode optical fiber and a respective one of the single mode optical fiber and the second single mode optical fiber.

[c9] The optical fiber link of claim 1 wherein at least one of the first and the second spatial mode converters comprises a lens imaging system having refractive and diffractive elements.

[c10] The optical fiber link of claim 1 wherein the second spatial mode converter reduces a number of higher-order modes propagating in the optical signal.

[c11] The optical fiber link of claim 1 wherein the second spatial mode converter reduces a number of lower-order modes propagating in the optical signal.

[c12] The optical fiber link of claim 1 wherein the second spatial mode converter reduces both a number of lower-order and a number of higher-order modes propagating in the optical signal.

[c13] The optical fiber link of claim 1 wherein the first spatial mode converter optically couples the single mode optical fiber to the multi-mode optical fiber so as to achieve a predetermined offset between a core of the single mode optical fiber and a core of the multi-mode optical fiber.

[c14] A method of increasing effective modal bandwidth of an optical signal transmitting through a multi-mode optical fiber, the method comprising:

spatial mode converting an optical signal, thereby reducing modal dispersion and increasing an effective bandwidth of the optical signal;
propagating the spatially mode converted optical signal through a multi-mode optical fiber; and
spatial mode converting the spatially mode converted optical signal propagated through the multi-mode optical fiber, thereby further reducing modal dispersion and further increasing the effective bandwidth of the optical signal.

[c15] The method of claim 14 further comprising generating the optical signal.

[c16] The method of claims 15 wherein the optical signal is generated with relatively low time varying phase and sideband information.

[c17] The method of claim 14 wherein the spatial mode converting at least one of the optical signal and the spatially mode converted optical signal reduces changes in effective modal bandwidth of the optical signal that are caused by thermal variations in the multi-mode optical fiber.

[c18] The method of claim 14 wherein the spatial mode converting at least one of the optical signal and the spatially

mode converted optical signal reduces changes in effective modal bandwidth of the optical signal that are caused by polarization effects in the multi-mode optical fiber.

[c19] The method of claim 14 wherein the spatial mode converting at least one of the optical signal and the spatially mode converted optical signal reduces changes in effective modal bandwidth of the optical signal that are caused by mechanical stress in the multi-mode optical fiber.

[c20] The method of claim 14 wherein the spatial mode converting at least one of the optical signal and the spatially mode converted optical signal reduces changes in effective modal bandwidth of the optical signal that are caused by optical fiber splices in the multi-mode optical fiber.

[c21] The method of claim 14 wherein the optical signal comprises more than one optical wavelength.

[c22] A multi-mode optical communication system comprising:

an optical transmitter that generates an optical signal at an output;

a first spatial mode converter having an input that is

coupled to the output of the optical transmitter, the first spatial mode converter conditioning a modal profile of the optical signal;

a multi-mode optical fiber having an input that is coupled to an output of the first spatial mode converter;

a second spatial mode converter having an input that is coupled to an output of the multi-mode optical fiber, the second spatial mode converter reducing a number of optical modes in the optical signal, wherein both the first and the second spatial mode converters increase an effective modal bandwidth of the optical signal; and

an optical receiver having an input that is coupled to an output of the second spatial mode converter, the optical receiver receiving the optical signal.

[c23] The communication system of claim 22 wherein the optical transmitter comprises an electro-absorption modulated laser.

[c24] The communication system of claim 22 wherein the optical transmitter comprises an integrated laser modulator.

[c25] The communication system of claim 22 wherein the optical signal comprises more than one optical wavelength.

[c26] The communication system of claim 22 wherein the second spatial mode converter reduces a number of higher-order optical modes in the optical signal.

[c27] The communication system of claim 22 wherein the second spatial mode converter reduces a number of lower-order optical modes in the optical signal.

[c28] The communication system of claim 22 wherein the multi-mode optical fiber comprises at least one section of single mode optical fiber.

[c29] The communication system of claim 22 wherein the optical receiver comprises an active filter that reconstructs dispersed optical signals received by the optical receiver.

[c30] The communication system of claim 22 wherein the optical receiver automatically adjusts at least one receiver parameter in order to compensate for changes in an average power of the received optical signal.

[c31] The communication system of claim 30 wherein the optical receiver automatically adjusts the at least one receiver parameter so as to maintain a substantially constant bit error rate as the average power of the received optical signal changes.

[c32] The communication system of claim 30 wherein the at

least one receiver parameter comprises receiver sensitivity.

[c33] The communication system of claim 22 wherein the optical transmitter comprises an optical intensity modulator, at least one parameter of the optical intensity modulator is chosen to suppress at least one of phase and sideband information in the optical signal.

[c34] The communication system of claim 33 wherein the at least one parameter of the optical intensity modulator comprises a bandwidth of the optical intensity modulator.

[c35] The communication system of claim 33 wherein the at least one parameter of the optical intensity modulator comprises an absorption spectrum of the optical intensity modulator.

[c36] The communication system of claim 33 wherein the at least one parameter of the optical intensity modulator comprises an extinction ratio of the optical intensity modulator.

[c37] The communication system of claim 33 wherein the at least one parameter of the optical intensity modulator comprises an absorption coefficient of the optical intensity modulator.

[c38] The communication system of claim 33 further comprising an optical isolator that substantially eliminates reflected optical signals from propagating into an output of the optical intensity modulator.

[c39] A multi-mode optical communication system comprising:

means for spatial mode converting an optical signal, thereby reducing modal dispersion and increasing an effective bandwidth of the optical signal;

means for propagating the spatially mode converted optical signal through a multi-mode optical fiber; and

means for spatial mode converting the spatially mode converted optical signal propagated through the multi-mode optical fiber, thereby further reducing modal dispersion and further increasing the effective bandwidth of the optical signal.